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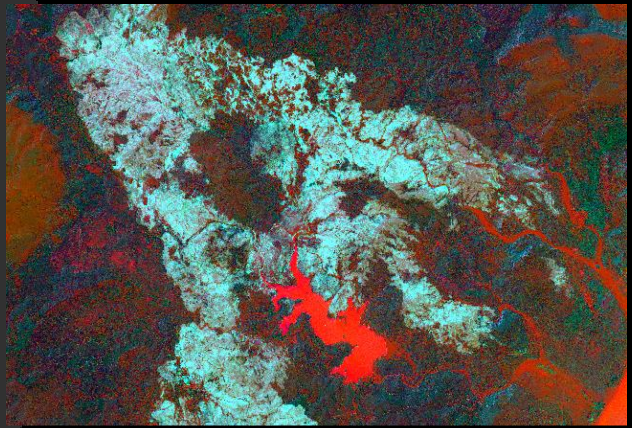
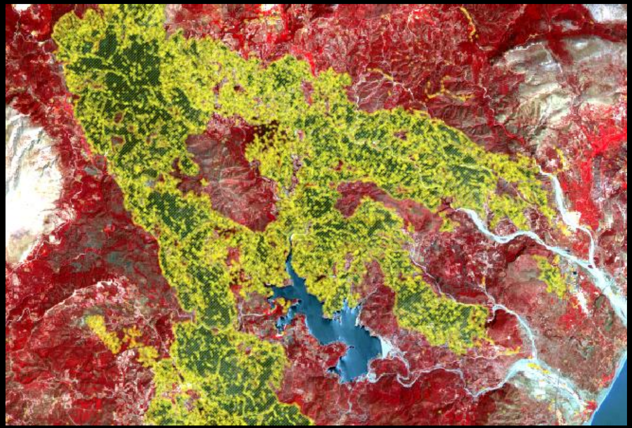
Introduction and Operation of EVAP module using QGIS



Outline

1. Overview
2. Introduction the operation procedure of EVAP module
3. Case studies
4. Conclusion

Overview

- In TASA (Taiwan Space Agency), an Emergent Value-Added Product (EVAP) module is established for acquiring satellite images to obtain the disaster affected area.
- A graphical modeler under QGIS tool box is developed to improve the efficiency and conveniency of EVAP workflow.
- The satellite data are required to be stacked into multispectral bands in the order of R, G, B, and NIR.
- Adding the band of Scene Classification(SCL) of Sentinel-2 L2A product to the EVAP module can further reduce the affect of cloud.
- “Changing image” can be generated though combining the three indices of the difference of NDVI and NDWI, and Change Vector Angle(CVA).
- Selecting the obvious area of the disaster in the “change image” to be the training data, the dynamic threshold can be established through the Gaussian statistical method, then to find the most of the change areas in the whole image.
- The Operation Procedure of the EVAP module will be introduced step by step .

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Introduction the operation procedure of EVAP module

The Preparation and EVAP Module

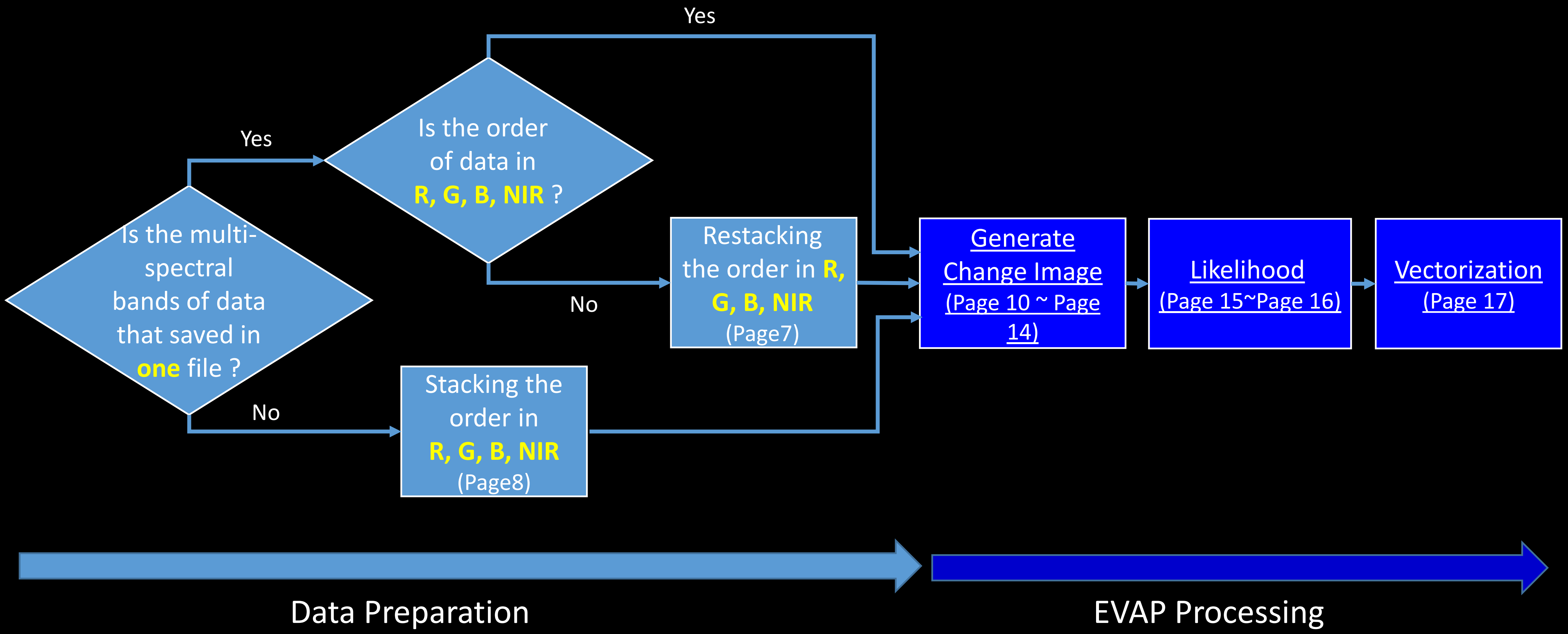
- Software : QGIS version 3.22
- Data Source :
  - The pre-disaster image.
  - The post-disaster image.
- Coordinate Reference System :
  - Setting the same CRS with raster files in project.

  Click here to watch video demonstration for Coordinate Reference System

- Data Preparation :
  - Stacking multi-spectral bands saved in one file with the sequence of R, G, B and NIR.
- Workflow of EVAP :
  - Change Image Generation
  - Likelihood processing
  - Vectorization

The icon indicates video demonstration links in corresponding page

Workflow



Yes
Is the order of data in R, G, B, NIR ?
Yes
Is the multi-spectral bands of data that saved in one file ?
Restacking the order in R, G, B, NIR (Page7)
No
Generate Change Image (Page 10 ~ Page 14)
Likelihood (Page 15~Page 16)
Vectorization (Page 17)
No
Stacking the order in R, G, B, NIR (Page8)
Data Preparation
EVAP Processing

Data Preparation (1/3)

- The EVAP module is designed for multi-spectral band data, the image data need to stack in one file with the sequence of R, G, B, NIR at first .

1. Multi-Spectral bands image of FORMOSAT-5 is saved in one file, which band sequence is R, G, B, NIR.

2. For other remote sensing data whose band of sequence is not stored in an order R, G, B, NIR, or each spectral band is saved in individual file, QGIS can generate correct band order image using the plugins “One Click Stacking” (with icon)

   A. Download and Plugin the “One Click Stacking” function in QGIS.
      a. Download the zip from QGIS website https://plugins.qgis.org/plugins/oneclickrasterstacking/
      b. Plugin the downloaded zip file Click here to watch video demonstration for Plugins

Data Preparation (2/3)

B. If the band order of multi-spectral image is not in R, G, B, NIR, please follow the step as bellow.

- Using the plugins “One Click Stacking “ to restack the multi-spectral band in one file with the sequence in R, G, B, NIR.

Steps of Restack

Click here to watch video demonstration for restack

Data Preparation (3/3)

C. If the Satellite data provide the individual file with each spectral band, like Sentinel-2, please follow the step as bellow.

- Using the plugins “One Click Stacking” to stack the multi-spectral band files into one file, which need spectral bands are R, G, B and NIR band, the sequence of the stacking file is R, G, B and NIR.

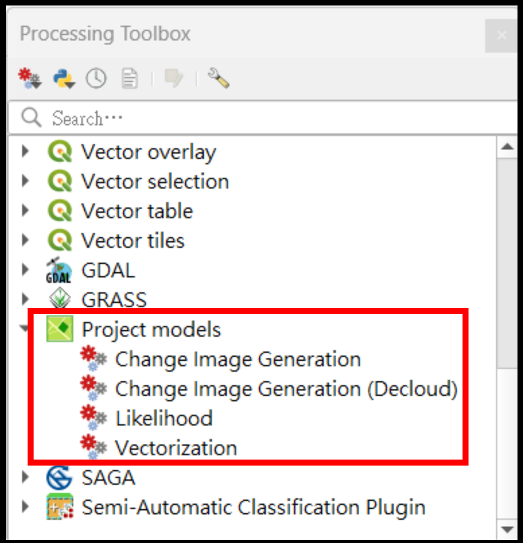
NOTE: Sentinel-2 Spectral bands name:

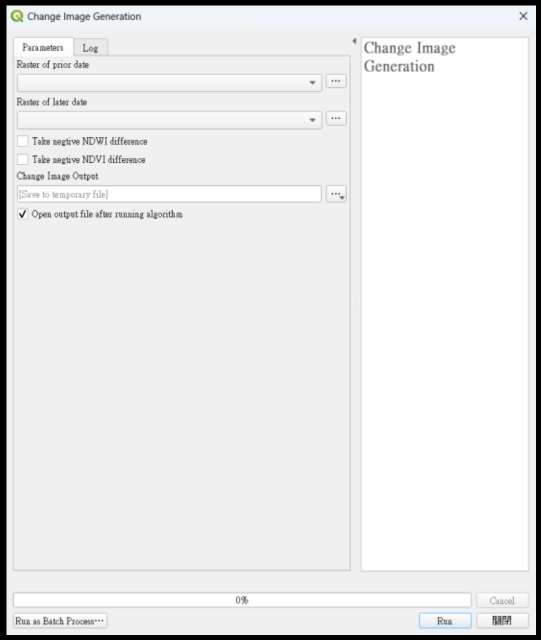
- B04 : Red band
- B03 : Green band
- B02 : Blue band
- B08 : Near Infrared band

Click here to watch video demonstration for stacking tool

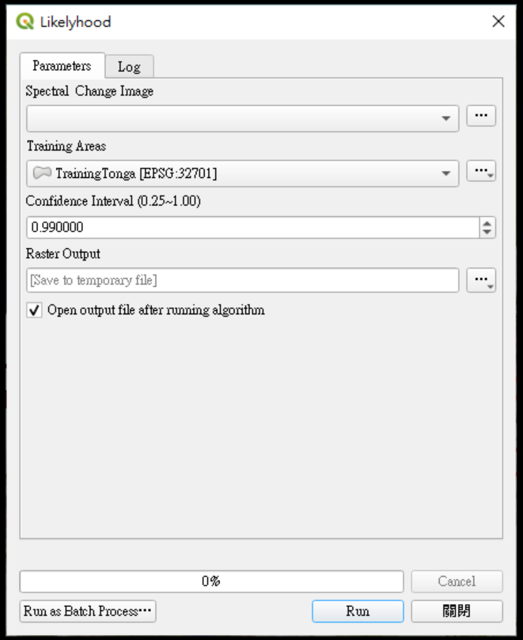
EVAP Processing

1. **Change Image generation:**
   QGIS graphical module was developed to apply spectral indices differences of NDVI and NDWI and output of Change Vector Angle.
2. **Likelihood :**
   Selecting "changed" areas as training data and use Gaussian statistical method generating the results.
3. **Vectorization:**
   By vectorizing the results of the 2nd step, complex areas can be further refined.





① Change Image generation



② Likelihood

③ Vectorization

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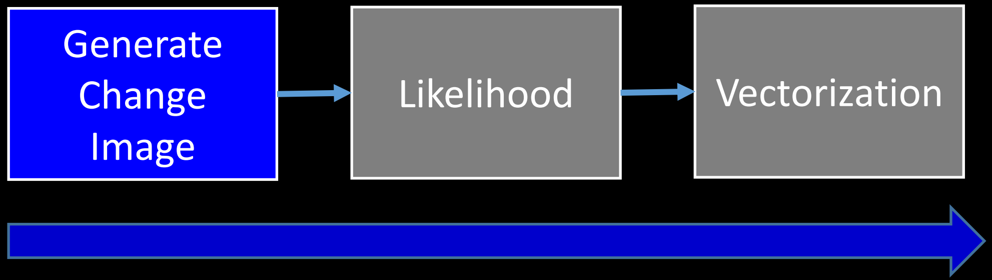
Change Image Generation of EVAP (1/5)



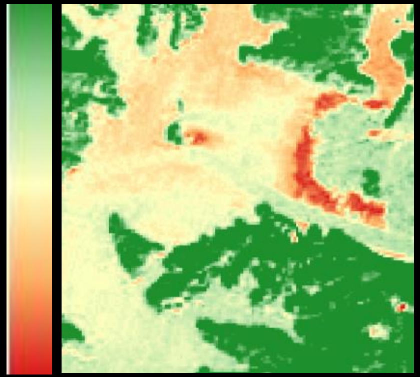
- Change Image generation
- Likelihood
- Vectorization

1. Spectral index
   - Normalized Difference Vegetation Index (NDVI)
   - Normalized Difference Water Index (NDWI)
   - Change Vector Angle (CVA)
2. Input data
   - Prior date image of disaster.
   - Later date image of disaster.

The "changed image" includes the information of (1) the difference of NDVI, (2)the difference of NDWI and (3)CVA .

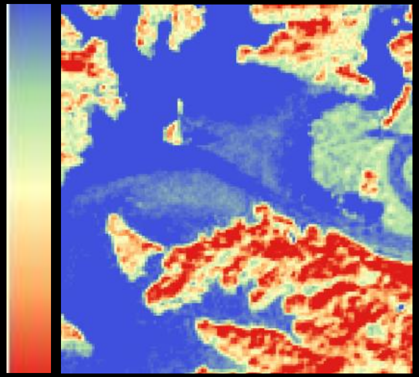
Natural color image

NDVI legend



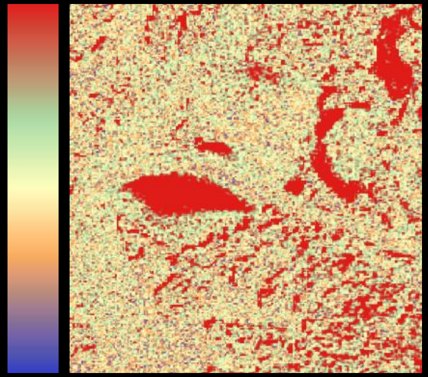
NDVI image

NDWI legend



NDWI image

CVA legend



CVA image

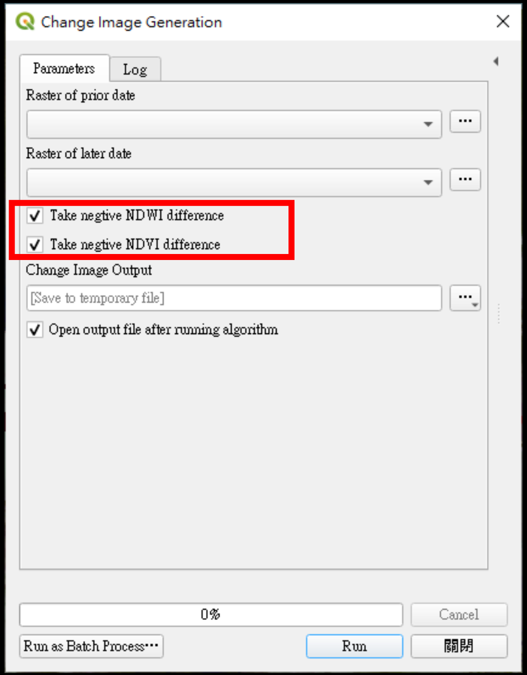
Change Image Generation of EVAP (2/5)
1.1 Spectral index

- "Changed image" is showed in Pseudo Color.
  1. **The difference of NDWI → R band.**
  2. **The difference of NDVI → G band.**
  3. **Change Vector Angle → B band.**

- If the number of the three indices is higher, the color of the "changed image" is more closed to white.
- Depending on the type of disaster event, if the index changes exhibit an opposite trend, the index differences are multiplied by −1 to ensure that the disaster affected areas are displayed in bright colors under the default enhancement settings in QGIS.
  - For example in **Flood case**:
    1. the NDWI of post-disaster is greater than that of pre-disaster, the difference of NDWI is **positive** → **do not select** "take negative NDWI difference" option.
    2. the NDVI of post-disaster is also smaller than that of pre-disaster, the difference of NDVI is **negative** → select "take negative NDVI difference" option.

Change Image Generation of EVAP (3/5)
1.2 Spectral index

- For example in **Wildfire case** :
  1. the NDWI of post-disaster is smaller than that of pre-disaster, the difference of NDWI is **negative** → select “take negative NDWI difference” option.
  2. the NDVI of post-disaster is also smaller than that of pre-disaster, the difference of NDVI is **negative** → select “take negative NDVI difference” option.



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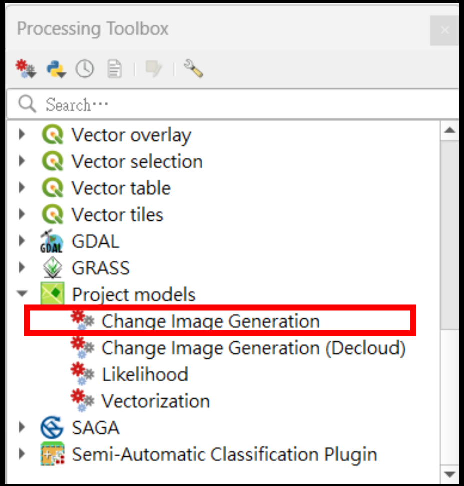
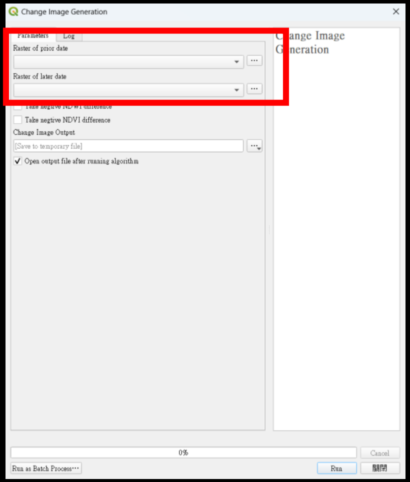
Change Image Generation of EVAP (4/5)
2.1 Input data without SCL

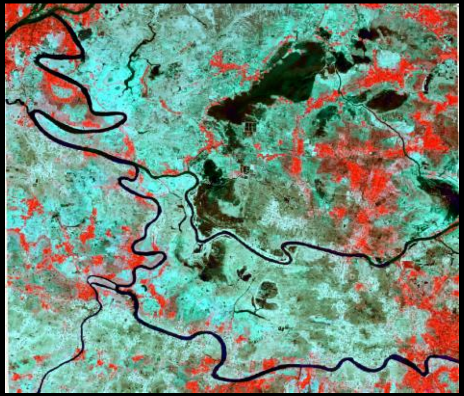
- Change Image generation
  - **Without SCL information**
  - With SCL information
- Likelihood
- Vectorization

If the data of satellite image without cloud information (band of Scene Classification, SCL), such as FORMOSAT-5, please select “Change Image generation” of the module.

Click here to watch video demonstration for Changing Image Generation





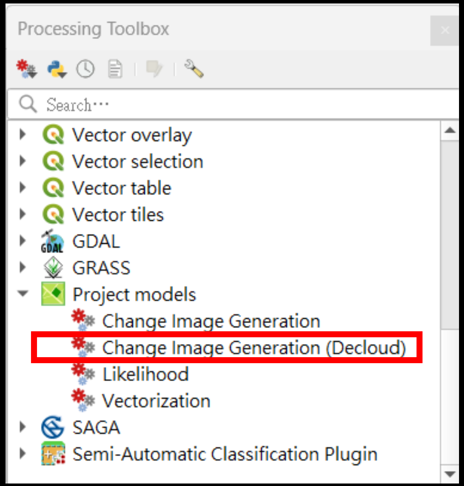


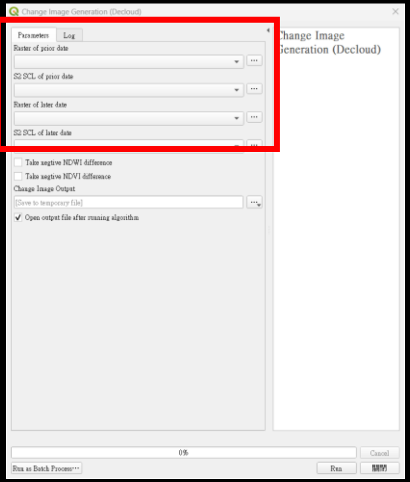
Change Image Generation of EVAP (5/5)
2.2 Input data with SCL

- Change Image generation
  - Without SCL information
  - **With SCL information**
- Likelihood
- Vectorization

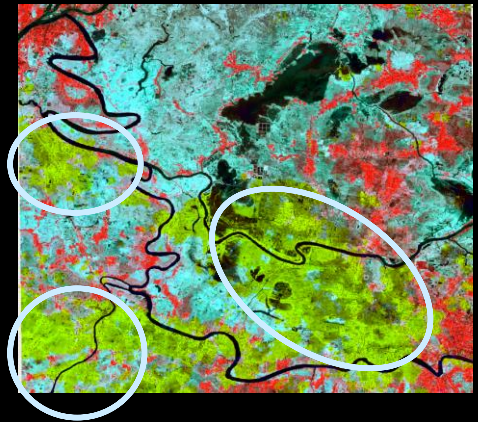
If the data of satellite image has cloud information, such as Sentinel-2 level-2A, please select "Change Image generation (declud)" of the module.

[Click here to watch video demonstration for Changing Image Generation with SCL]





○ Cloud information



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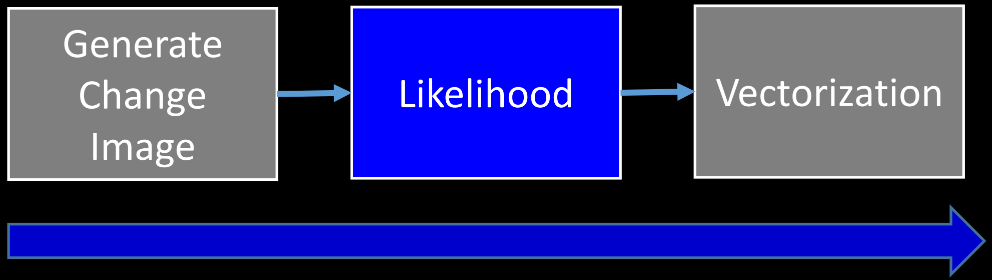
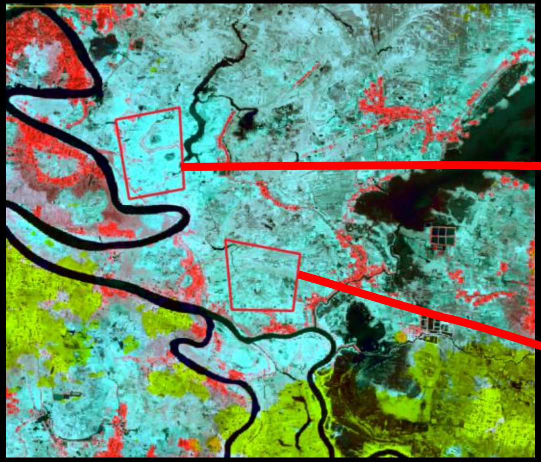
Likelihood of EVAP (1/2)



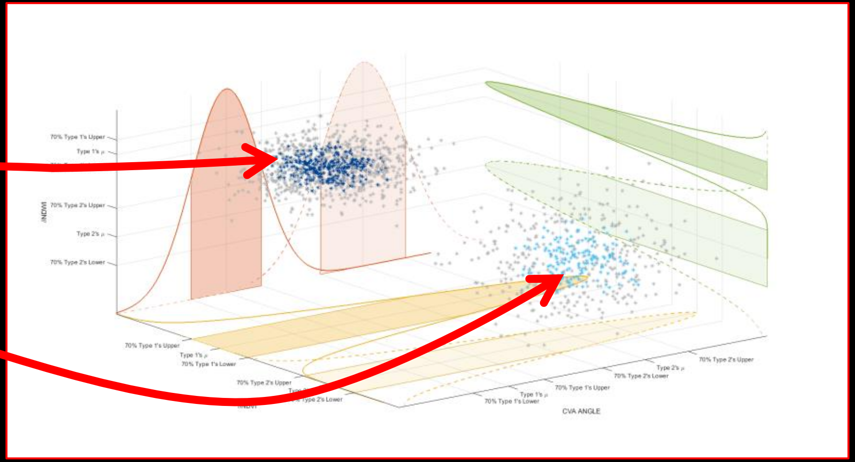
- Change Image generation
- Likelihood
- Vectorization

Gaussian statistics

- A larger difference between pre-disaster and post-disaster images corresponds to a higher detection probability.
- By selecting a small portion of the changed area as training data, a dynamic detection threshold can be established through Gaussian statistical method to identify rest of the changes in the images.
- To ensure better quality of the training data, a confidence interval is incorporated into the processing.



Changed Image



Gaussian statistical approach with confidence intervals

Likelihood of EVAP (2/2)

- Change Image generation
- Likelihood
- Vectorization

1. **Create training data**

Choosing a small portion of changed area as training data.

Click here to watch video demonstration for Creating the training data

2. **Likelihood**

Establishing dynamic threshold thought the Gaussian statistical method.

Click here to watch video demonstration for Likelihood

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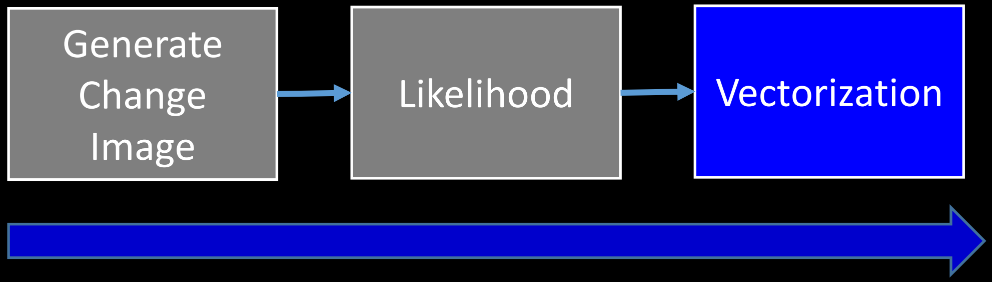
Vectorization of EVAP



- Change Image generation
- Likelihood
- Vectorization

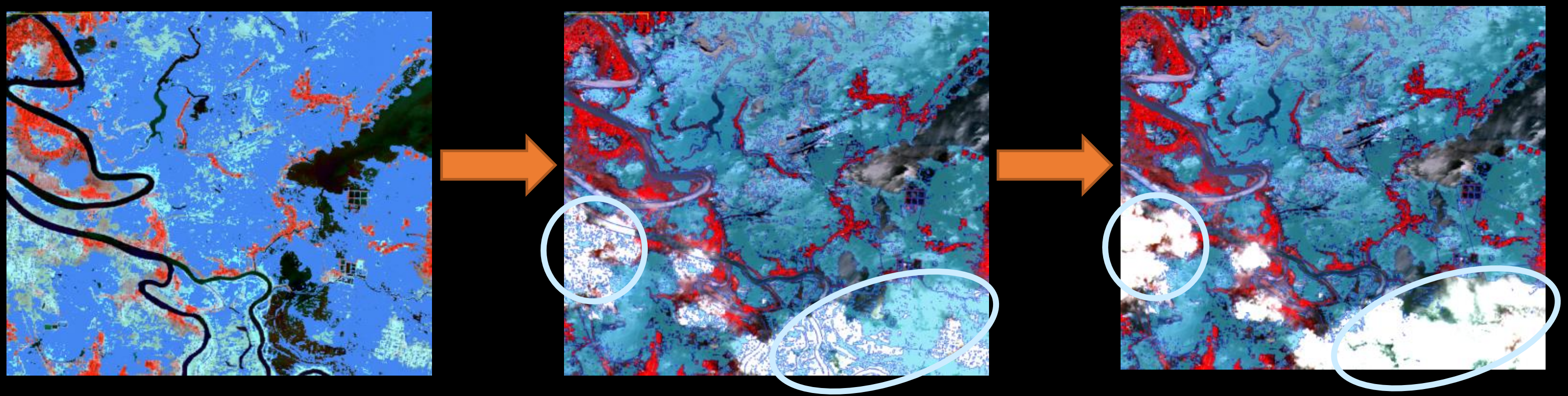
Input Data
- Final Change Image

Processing
- Raster to vectorization

Click here to watch video demonstration for Vectorization

- Manual editing if needed

Click here to watch video demonstration for manual editing the shapefile



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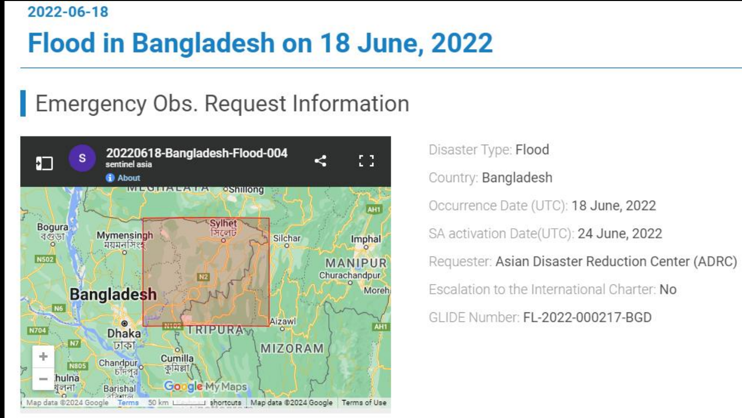
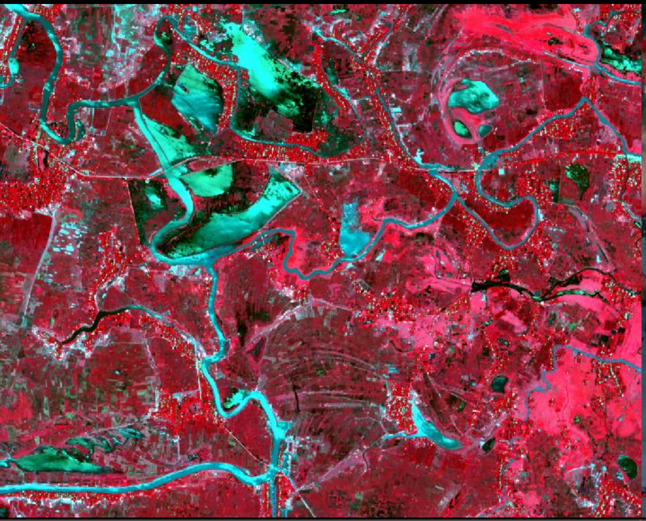
Case studies



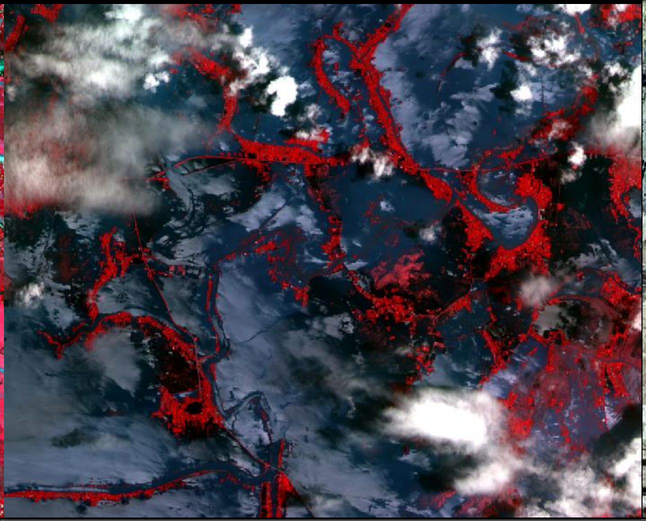
Case studies (1/2)

Flash Flood in Bangladesh

1. The flood that occurred in Bangladesh in 2022.
2. Comparing the pre- and post-disaster images reveals the flood’s extensive impact, covering most of the area.
3. Using the EVAP module, the affected area is estimated to be approximately 66.8 km^2.

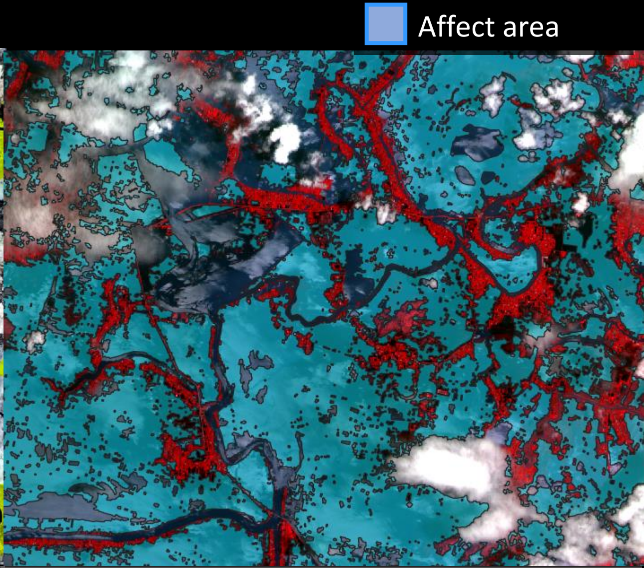


Prior Sentinel-2 2022/04/21



Post Sentinel-2 2022/07/10

Change Image



Affected Area

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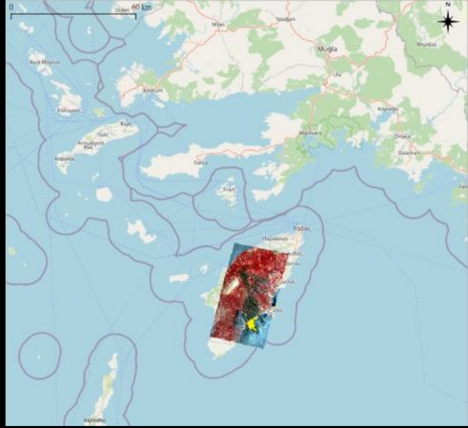
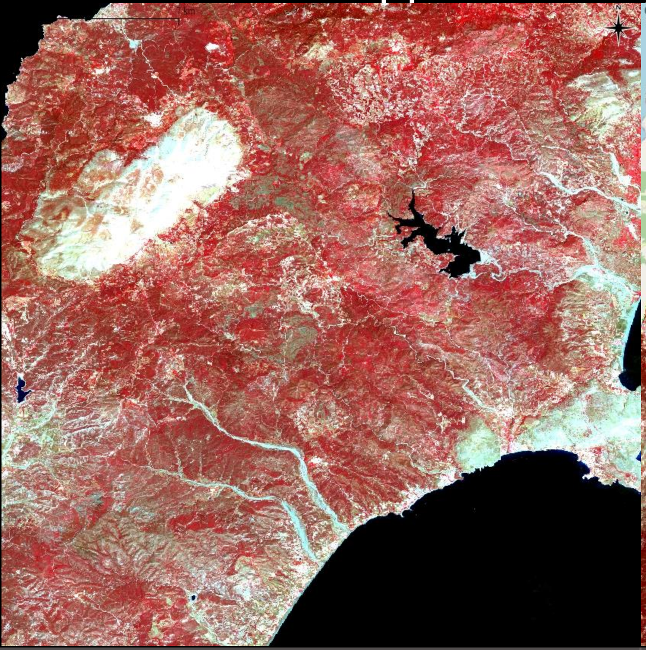
Case studies (2/2)

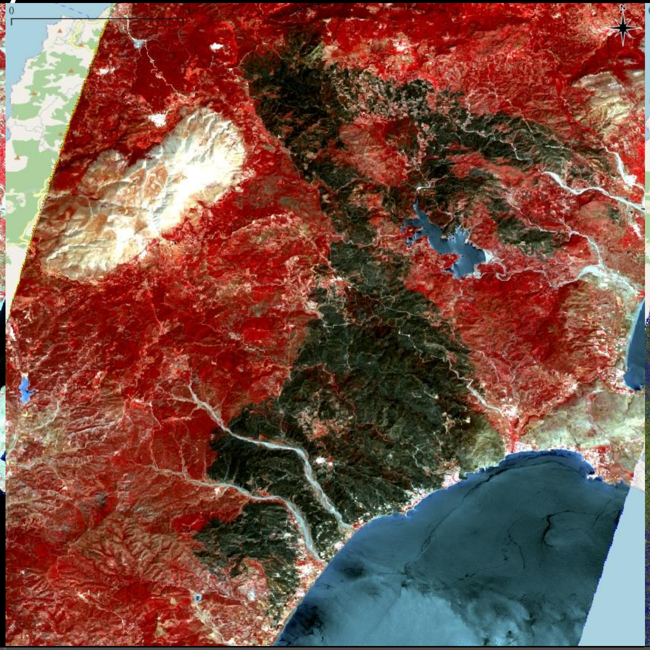


Wildfire at Rhodes Island in Greece

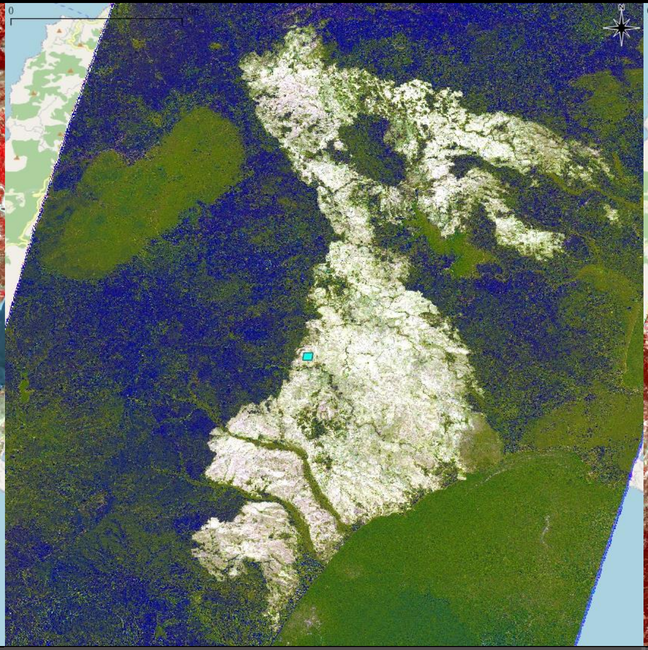
1. The wildfires that occurred in Greece in 2023.
2. After the wildfire, the most significantly changed areas are clearly identifiable.
3. Using EVAP module, the affected area of the satellite data is estimated approximately 163.96 km^2.



Prior Sentinel-2 2023/07/13

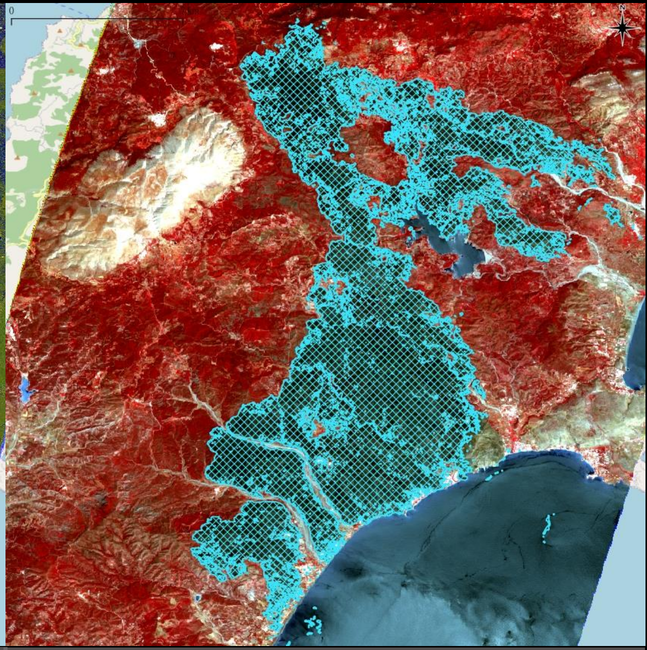


Post FORMOSAT-5 2023/07/30



Change Image

Affect area



Affected Area

Conclusions

- With the graphical modules provided by QGIS, the coding process can be implemented efficiently and visualized through a user-friendly interface.
- The identified affected areas from EVAP module can be directly utilized to generate reports by QGIS.
- Applying a Gaussian statistical approach with confidence interval constraints, reliable affected areas can be effectively identified.
- Ensuring high-quality results, manual editing is still required in certain complex cases.